Compensatory mitigation for marine bycatch will do harm, not good

Many argue that we must embrace market incentives to effectively conserve species. Following this trend, Wilcox and Donlan (*Front Ecol Environ* 2007; **5[6]**: 325–331) propose economically-based compensatory mitigation for marine bycatch (CMMB), in which lucrative fishing and associated bycatch are allowed to continue with compensatory fees paid to fund conservation actions on the terrestrial islands where some marine species breed. Wilcox and Donlan illustrate this approach with a seabird example but suggest CMMB is broadly applicable.

CMMB represents a major paradigm shift in existing strategies for reducing impacts of marine bycatch via gear modification, seasonal and area closures, and, in some cases, fishery closures. Despite the lack of pilot data, efforts are underway in national and international policy arenas to advocate the CMMB approach (http://advancedconservation.org). Given the potential speed of this policy shift – and its obvious allure for the fishing industry – we outline why CMMB could only rarely succeed in reducing or offsetting the effects of marine bycatch mortality and would often worsen bycatch impacts:

1. CMMB fails to protect the vast majority of bycatch-impacted species for which no terrestrial mitigation is possible. Bycatch affects a taxonomically and ecologically diverse suite of species, and most have no terrestrial breeding phase or equivalently localized and understood life stage susceptible to management (Figure 1). Reducing bycatch helps broad groups of impacted species, but CMMB aids only a select few, leaving the rest to suffer continued or intensified mortality.
2. Wilcox and Donlan compare conservation actions based on increase in λ per dollar spent, but this return-on-investment approach is only valid if each action achieves the ecological bottom line of reversing population declines. Nearly all bycatch-impacted species are long lived and slow maturing and will remain imperiled in the face of significant adult mortality at sea, regardless of "cost-effective" CMMB on land.
3. Bycatch generally impacts individuals from many breeding sites, but rarely are all breeding colonies heavily impacted by terrestrial threats that can be addressed through CMMB. In this situation, localized mitigation activities have far less efficacy than non-spatial models suggest.
4. Assessing CMMB requires more complex accounting than that presented by Wilcox and Donlan. CMMB fees could be assessed as a per boat charge, or as a tax on fish landed per boat or bycatch per boat. The first two offer no individual incentives to reduce bycatch, potentially increasing bycatch rates. The third requires observers on *every* boat, a hefty expense that must be factored into CMMB costs.
5. The favorable results of modeling CMMB for flesh-footed shearwaters on Lord Howe Island appear to rest on several flawed assumptions. Most critically, all egg-to-fledging mortality (except that caused by death of a parent) is assigned to rat predation. Thus, with rat eradication, all eggs and chicks of living parents have 100% survivorship, an unrealistic assumption for any shearwater population. Worse, Wilcox and Donlan's key data source for the modeled population dismisses rat impacts, stating: "productivity…[was] not suggestive of a population suffering a high rate of predation, and there was no direct evidence of rats preying on flesh-footed shearwater eggs or chicks" (Priddel *et al.* 2006). Even using this and other faulty assumptions,

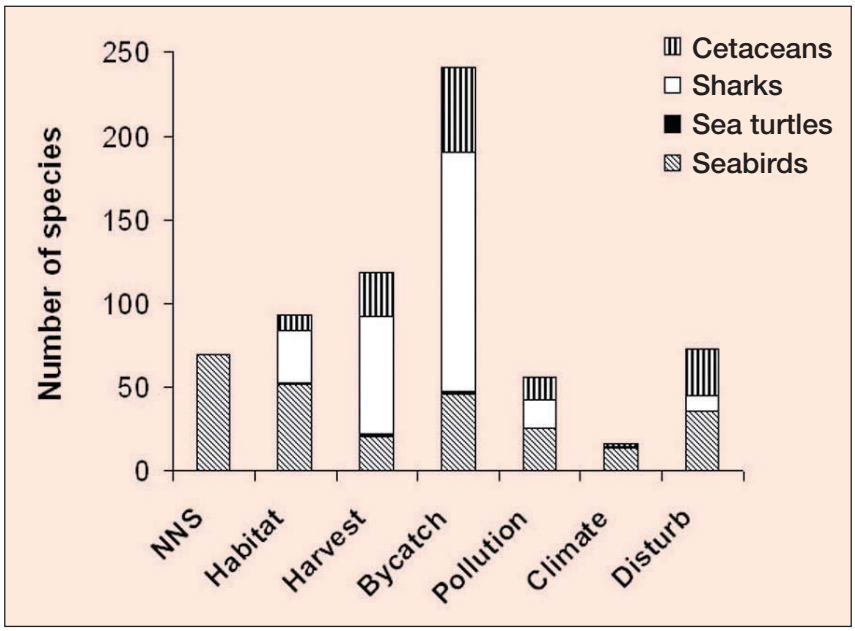

Figure 1. *Total number of species of cetaceans, sharks, sea turtles, and seabirds in the IUCN red list database (www.iucnredlist.org) affected by the following threat categories: NNS = non-native, invasive species; Habitat = habitat destruction and degradation; Harvest = harvesting; Bycatch = accidental mortality from fisheries bycatch; Pollution = land and water pollution; Climate = air pollution and climate change; Disturb = human disturbance, persecution, noise pollution, and collisions. Only seabirds are listed as threatened by NNS.*

we are unable to replicate Wilcox and Donlan's results, some of which are ecologically nonsensical. Using their published model structure, parameter estimates, and assumptions, neither rat eradication nor bycatch elimination alone can boost λ over one or produce the stated relative effects. The reported 63% increase in λ over baseline implies eradication raises λ to ~1.5. Given a fixed clutch size of one, this requires essentially zero mortality for all ages and successful reproduction of all birds in all years starting at age one, a biological impossibility. The greater early benefits of rat eradication reported by Wilcox and Donlan are fleeting and irrelevant for management, arising when exaggerated reproduction produces transient increases in juveniles prior to their exposure to bycatch mortality. Our corrected demographic model indicates that only bycatch reduction can avert declines for this seabird.

The wide distribution of the many species impacted by fisheries bycatch means that even well-conceived CMMB approaches will rarely, if ever, benefit marine communities as a whole and should not derail boat-based conservation efforts. More broadly, Wilcox and Donlan's proposal highlights the complexity of integrating economics and conservation so that market incentives encourage reductions in overall impacts and so that cost-effectiveness does not distract from basic ecological goals.

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Priddel D, Carlile N, Fullagar P, *et al.* 2006. Decline in the distribution and abundance of flesh-footed shearwaters (*Puffinus carneipes*) on Lord Howe Island, Australia. *Biol Conserv* **128**: 412–24.

The authors reply

Doak *et al.* highlight some of the many challenges of incorporating compensatory mitigation into fisheries management. However, they take a naïve view of fisheries management, and ignore important aspects of our paper. Their "either/or" view of bycatch management is contrary to our argument that "compensatory mitigation, in *conjunction* with direct bycatch-mitigation efforts, is a…feasible strategy for *seabird* conservation". We are not proposing a "major paradigm shift", but emphasizing a hierarchy of strategies from the Convention on Biological Diversity: first, avoidance, then direct mitigation, and, finally, offsets (ie compensatory mitigation). Avoidance is difficult in our case study, as the shearwaters overlap the entire fishery. Direct mitigation (ie modified fishing gear) is required by law. Yet, the mitigation is not entirely effective, and thus we propose incorporating offsets. In reality, even the most responsible fisheries catch some seabirds. If offsets were available to address residual bycatch, for the first time a bycatch-neutral fishery becomes a viable goal. Below, we address some other points raised by Doak *et al.*

1 and 3. Contrary to Doak *et al.*'s claims, our discussion was explicitly limited to seabirds, briefly mentioning sea turtles. They suggest that "reducing bycatch helps broad groups of impacted species [their Figure 1], but CMMB aids only a select few". Yet, measures for avoiding different taxa are generally unrelated. Tori lines reduce seabird bycatch, but not sea turtle, shark, or cetacean bycatch. Both *direct* and compensatory mitigation will benefit some species and not others, and may have unexpected negative impacts on others. For example, circle hooks reduce sea turtle bycatch in some cases, but may increase shark bycatch (Read 2007). It is reckless to skirt the trade-offs inherent in any approach.

2. Doak *et al.* claim that our analysis is only "valid if each action achieves [the goal]…of reversing population declines". While reversing declines is the goal of conservationists (including ourselves), it is not the goal of fisheries managers. Their goal is to reduce the impact of fisheries on non-target species, and as such a return-on-investment perspective is entirely appropriate.

2. Doak *et al.* also fail to note that we acknowledge the challenges of offsets for long-lived species (p 328).

4. We clearly propose individual levies, tied to vessel performance, as an incentive instrument. Moreover, any measure for reducing bycatch – avoidance, direct mitigation, or offset – requires monitoring to assess performance and assure compliance. Observers, Doak *et al.*'s "hefty expense", are an essential part of effective management, irrespective of compensatory mitigation.

5. Doak *et al.* raise valid points regarding the technicalities of our model. However, we disagree that our assumptions (or model) are flawed or the conservation gains incorrect. We explicitly assumed no other mortality sources – ignoring bycatch in other fisheries, habitat loss, and many other factors – in order to focus on the eradication–closure trade-off.

Our assumption that rat predation is important is reasonable. The productivity for flesh-footed shearwaters is well below most reports in the literature, and in the absence of an identified cause, may be due to rat predation. While not documented on Lord Howe Island, no explicit studies have

been undertaken. Rat predation on burrow-nesting seabirds is widely documented; Jones *et al.* (in press, including two co-authors among Doak *et al.*) document rat impacts on eggs, chicks, and adults for eight congeners of flesh-footed shearwaters.

The values we estimate are also reasonable. Our model's estimate of productivity in the absence of rat predation and bycatch was ~0.95, which is at the upper end of empirical values for shearwaters, as one would expect in a population model assuming no anthropogenic impacts (range = 0.26–0.93, n = 15 species). Igual *et al.* (2006) demonstrated that rats reduce productivity of Cory's shearwaters by 70%, which is within 1% of our value. While it is possible that our model's predation effect is higher than the real value, the conclusions remain valid.

Finally, Doak *et al.*'s opinions illustrate two additional challenges to incorporating offsets into management. First, conservationists must resist viewing conservation strategies as "either/or" silver bullets, and instead must see them as tools to help solve conservation problems with varying intricacies and options. Second, we must vet conservation interventions against the counterfactual (eg existing *best practices* not preventing *all* seabird bycatch), rather than the vague assertion that existing methods will prevent all bycatch.

Poor governance and absence of incentives – not management tools – are the premier issues in fisheries. There are challenges and risks associated with compensatory mitigation. However, business-as-usual is unsatisfactory and misses opportunities for conservation gain. While it is important to be critical of novel approaches, we must do so without prejudice. The responsibility for developing practical solutions for conservation problems falls in part on the shoulders of academia and NGOs – it is essential that we work together productively to meet this obligation.

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